NEGATIVE HELIOTROPISM OF UREDINIOSPORE GERM-TUBES[1]

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During the course of some germination tests with urediniospores of *Puccinia Rhamni* (Pers.) Wettst. in the spring of 1913 an apparent negative heliotropic reaction by the germ-tubes was seen. The spores had been sown in a drop culture exposed to a unilateral illumination on a window sill and a high per cent. of the tubes had grown directly away from the light. Subsequent tests with controls in darkness substantiated the first observations. A search of the literature brought forth a single mention of a heliotropic reaction in germinating rust spores. Ward,[2] referring to a series of germination studies with urediniospores of *Puccinia dispersa*, has written: "My reasons for varying the direction of incidence of the light in certain cases were based on some results (as yet inconclusive) that the germ-tubes exhibit heliotropic curvatures."

That the sporidial germ-tubes of *Puccinia malvacearum* react negatively to daylight has been shown recently by Robinson,[3] but aeciospore germ-tubes of *Puccinia Poarum* were found to be indifferent. Germ-tubes of conidia of *Botrytis* sp. also grew away from light but those of other non-rust fungi tested *Alternaria* sp., *Penicillium glaucum* and *Peronospora parasitica*, were indifferent according to Robinson.

During the past fall, 1914, the study of the effect of light on germinating urediniospores of *Puccinia Rhamni* was again taken up. Urediniospores were obtained at first from the field and stored in gelatin capsules and later from cultures on oat plants grown in the greenhouse. The urediniospores of this species are especially suitable to daylight tests on account of their quick germination and the rapid growth of their germ-tubes. In the tests made the germ-tubes averaged in growth once to twice the spore length in as many hours and four to six times in three to four hours.

[1] Read before the American Phytopathological Society at the Philadelphia meeting, January 1, 1915.

[2] Ward, H. M. Ann. Bot. **16**: 267. 1902.

[3] Robinson, W. Ann. Bot. **28**: 331–340. 1914.

The following method of germination was chiefly used. Dry urediniospores were dusted over the surface of a drop of a 5 per cent non-nutrient gelatin placed on a glass slide in a Petri dish containing a moist filter paper. The Petri dish was then placed in a dark box on a window ledge with an aperture, 2.5 cm. in diameter, towards the window. All tests were made with diffused daylight. Controls were maintained in darkness.

In all of the ten or more tests that were made with an exposure of four or five hours to a unilateral illumination more than four-fifths of the germ-tubes responded negatively to the light stimulus. A count of some 200 germ-tubes in three tests gave an average of 86 per cent that had grown away from the light (*fig.* 1*a*). A small part of the remainder

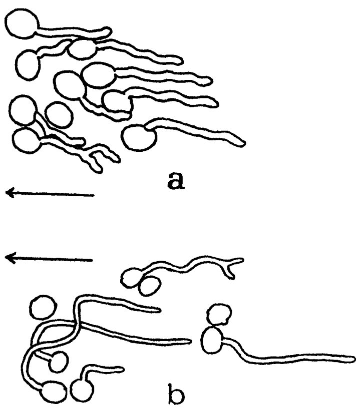

FIG. 1. Germinating urediniospores of *Puccinia Rhamni; a* and *b*, exposed for three hours to a unilateral illumination; *c*, germinated in darkness. The arrows indicate the direction from which light was admitted.

had grown towards the light and a large part were recorded as transverse to the incidence of light. The germ-tubes of the controls in darkness grew in all directions (*fig.* 1*c*).

Urediniospores of *Puccinia Rhamni* have from six to eight germ-pores that are distributed at approximately equal distances apart over the spore surface. A study of the germ-tubes that had grown away from the light showed that the large majority of them has issued from pores located on the part of the spore wall farthest from the light (*fig.* 2). Others that had issued from pores on the part of the wall towards the light or transverse to it had soon changed their direction

of growth by a turn of 90° or 180° and had then grown away from the light (*fig.* 1*b*). The incidence of light, therefore, not only had a pronounced effect in determining the direction of growth of the germ-tubes, but also determined to a considerable degree the approximate part of the spore wall at which the germ-tube issued, *i. e.*, the part farthest from the light. The other pores on the shaded part of the spores were likewise stimulated to some degree and a noticeable swelling of their gelatinous contents was often apparent. Sometimes

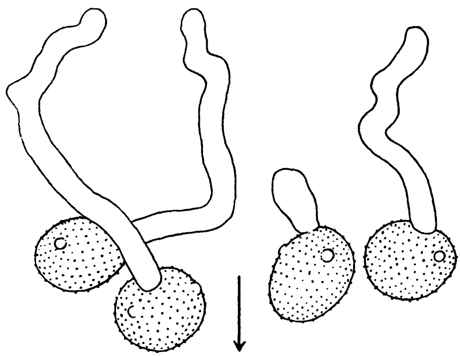

FIG. 2. Germinating urediniospores of *Puccinia Rhamni* after an exposure of three hours to a unilateral illumination. The arrow indicates the direction from which light was admitted.

two germ-tubes issued from the shaded side but one of them soon outgrew the other. When the spores were germinated in darkness the tube issued from any one of the pores.

No theory to account for the presence or significance of more than one germ-pore in urediniospores has been advanced. If a possible explanation in terms of advantage is permissible, it seems reasonable to assume that a germ-tube in nature arising from the shaded side of the spore, adjacent to the leaf surface, would be in a more advantageous position to effect an entrance into a stoma than one arising from the non-shaded side, away from the leaf. A urediniospore with several pores should, therefore, have a better chance of producing an infection than one with a single pore.

The importance of these light reactions of germinating urediniospores from a pathological viewpoint may be found in the possible explanation of certain phases of infection that they suggest. The

nature of the stimulus, or combination of stimuli, that is responsible for the stomatal entrance of germ-tubes of rust spores and of other parasitic fungi has not been definitely ascertained. The more general belief is that the host exerts a positive chemotropic influence on the germ-tube, but the failure of attempts to prove that chemotropism plays an important part in this process has been practically universal. If a chemotropic attraction by the host is to be assumed in the rusts it must be considered a very general property of plants and not a specific property of the hosts alone, since urediniospore germ-tubes of a number of rusts have been shown by Gibson[4] to enter the stomata of non-hosts as well as those of their hosts. That positive hydrotropism may partially explain stomatal entrance is suggested by the work of Balls[5] and of Fulton[6] but it is doubtful that this can be a factor of primary importance. What part the action of light may play in bringing about the stomatal entrance of the urediniospore germ-tube is as yet a matter of conjecture. It seems quite probable, however, that a continued turning away from light may serve to bring the germ-tube into close contact with the surface of the host and be chiefly responsible for its entrance into the stomatal opening. This is, of course, only a preliminary stage of infection. The success or failure of the attack on the host tissue from the substomatal chamber cannot be directly influenced by light.

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[4] Gibson, C. M. New Phytol. 3: 184–191. 1904.
[5] Balls, W. L. New Phytol. 4: 18–19. 1905.
[6] Fulton, H. R. Bot. Gaz. 41: 81–108. 1906.